Rethinking the Philosophical and Theoretical Foundations of Organizational Neuroscience: A Critical Realist Alternative

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ABSTRACT

Stimulated by the growing use of brain imaging and related neurophysiological techniques in psychology and economics, scholars have begun to debate the implications of neuroscience for management and organization studies (MOS). Currently, this debate is polarizing scholarly opinion. At one extreme, advocates are calling for a new neuroscience of organizations, which they claim will revolutionize understanding of a wide range of key processes, with significant implications for management practice. At the other extreme, detractors are decrying the relevance of neuroscience for MOS, primarily on philosophical and ethical grounds. The present article progresses this debate by outlining an intermediate, critical realist position, in which the insights of social neuroscience are one of a number of convergent building blocks that together point toward the need for a more embodied and socially situated view of cognition in management and organizations.

> Using single-dose psychostimulants to manipulate dopamine levels, we have seen modulation of risky decision-making … Therefore, it might be possible to enhance entrepreneurship pharmacologically. (Lawrence et al., 2008: 169)

> Neurological assessment might ultimately be used to help facilitate the selection and placement of leaders in organizations. In short, neurological assessment may provide a new "microscope" to look at the biological sources of leader behavior. (Balthazard et al., 2012: 256)

> Interestingly, even advocates of applying neuroscience to the work context admit that it is not difficult to discern that approaches to optimize the workforce can potentially be construed as dehumanizing employees ... by dehumanizing employees, I mean the neurological modification of employees for the benefit of the organization. (Lindebaum, 2013: 298)

> I have to tell you that neuroscience isn't the panacea it may appear to be. You won't be able to use brain scanning to help you tell whether your leading R&D scientist has had a genuine eureka moment. Nor will you be able to use a scanner to choose the right CEO to turn your struggling company around. Not next year. Not the year after. Not in our lifetimes. (Gazzaniga, 2006: 66)

Introduction

Scholarly opinion in the field of management and organization studies (MOS) is currently divided concerning the possibilities and pitfalls of neuroscience as a basis for enriching its science and practice. At one extreme, advocates such as Becker and colleagues (2011) are calling for a new, biologically rooted, subfield that aims to map neural mechanisms as the prime causes of organizational behavior (see also Lee, Senior and Butler, 2012; Senior, Lee and Butler, 2011). At the other extreme, scholars are warning that applying neuroscience to MOS is a dangerous distraction (McLagan, 2013; Lindebaum, 2013). Lindebaum and Zundel (2013: 862), for instance, argued that the problems inherent in reducing explanations of complex social phenomena to the neurological level make it "impossible to logically and consistently correlate" what is measured in neuroscience to organizational phenomena such as leadership. Similar debates are taking place within the microfoundations project in strategy and organization theory, where scholars are considering the insights of neuroscience to explicate the fundamental mechanisms underpinning the actions of economic decision makers at the individual, team, organizational, and inter-organizational levels (Gavetti et al., 2007; Hodgkinson and Healey, 2011; Powell, 2011; Powell et al., 2011; Teece, 2007).

It may be tempting to adopt the pragmatic view that MOS scholars should simply get to work with neuroscience and judge the results on their merits. Indeed, there are signs that this is already happening, with a rush to place leaders, managers and entrepreneurs in brain scanners (Balthazard et al., 2012; Hannah et al., 2013; Laureiro-Martínez et al., 2010, in press; Lawrence et al., 2008). However, as Glimcher (2011) cautions in the context of neuroeconomics, historical attempts to fuse the social and natural sciences are littered with hundreds of papers drawing faulty conclusions because of confusion about basic philosophical issues. With this in mind, it is worth noting that MOS has already experienced an aborted foray into neuroscience, based on the earlier body of work known popularly as split-brain research (Gazzaniga, 2006; Mintzberg, 1976; Robey and Taggart, 1981). To avoid a reoccurrence of such problems, some philosophical and theoretical heavy lifting is required.

In this article, we argue that if MOS is to benefit meaningfully from neuroscience, it must establish a viable means of engaging with theoretical and empirical developments in this rapidly expanding field, without losing sight of the *socially embedded nature* of organizational life. Accordingly, we identify two bridging devices that, once in place, should enable more productive and robust exchanges between *social neuroscience* and MOS. The first is philosophical in nature and concerns the use of critical realism as an epistemological and ontological framework that locates neuropsychological processes as one of several significant generative mechanisms that explain behavior in the workplace. Critical realism helps to avoid problems associated with reductionism and offers emergence as an alternative mode for explaining organizational behavior with reference to bio-physical roots (including neurophysiological processes). The second device is theoretical in nature and concerns the adoption of socially situated cognition as an overarching conceptual framework that connects brain, body and mind to social, cultural, and environmental forces, as significant components of complex organizational systems. Socially situated cognition locates the brain not as the primary causal determinant of organizational behavior but as one component, albeit a directing one, underpinning the cognitive mechanisms that enable the execution of complex work-related tasks. In combination, these two devices provide a realist, socially situated view of the microfoundations of organizational behavior, whereby the analysis of neurophysiological processes plays a contributory, but not primary, role in advancing the science and practice of management and organization.

Contrary to the anti-reductionist view that drawing on neuroscience diminishes the importance of social context, our analysis demonstrates how it points the way toward new microfoundations for understanding behavior in organizations, ones that posit a greater role for embodied and socially situated cognition as generative mechanisms of individual and collective action in the workplace. Below, we provide examples to illustrate how socially situated cognition research can bring the basic insights of social neuroscience to bear on the problems of MOS by changing theory rather than changing methods. From this standpoint, the primary benefit of social neuroscience for advancing MOS lays less in placing employees in brain scanners; indeed, arguably, such an exercise becomes unnecessary.

To progress the debate regarding neuroscience in MOS beyond unbridled advocacy versus outright rejection, we first revisit the hierarchical reductionist rationale for organizational neuroscience before considering recent anti-reductionist critiques of this approach. Next, we outline the benefits of critical realism as a viable alternative. Finally, we demonstrate how socially situated cognition complements critical realism, as an essential device for mediating between fundamental neuropsychological mechanisms and higher-level organizational behavior, conceived broadly, so as to encompass individual, group, organizational, and inter-organizational levels.

Limitations of Hierarchical Reductionism for Linking MOS and Neuroscience

Decomposing psychological and brain functions to the molecular level, "neuroscience has pursued reductionism with ruthless determination" (Becker and Cropanzano, 2010: 937). Extending this approach, Becker, Cropanzano and Sanfey (2011) advocate *hierarchical* reductionism as the primary philosophical basis for introducing neuroscience to MOS. As a general philosophy, this approach involves explaining higher level (i.e. more abstract) phenomena in terms of lower levels of analysis (Nagel, 1961). In the case of organizational neuroscience, hierarchical reductionism involves explaining behavioral phenomena such as attitudes and justice in terms of individual brain activity. Hierarchical reductionism thus champions the basic proposition that organizations are reducible to groups, which in turn are reducible to individuals, whereupon individuals can then be decomposed into discrete brain processes (Becker, Cropanzano and Sanfey, 2011).

Becker and colleagues (2011) claim that the value of neuroscience is that it inserts an additional level of explanation into organizational analysis, i.e. the neurological level, that enables researchers to drill down into the "primal causes of behavior" (Becker, Cropanzano and Sanfey, 2011: 934). This form of reductionism necessarily privileges lower levels of explanation over higher ones and in so doing posits neurophysiological processes as the fundamental drivers of individual, group and organizational phenomena. Hence, it legitimizes a race to the bottom in the search for ultimate causation. For example, Becker and colleagues suggest that analyzing mirror neurons will ultimately uncover the fundamental, implicit causes of workplace discrimination and resistance to change. In a related vein, they claim that examining activity in specified brain centres will enable researchers to ascertain whether concern for organizational justice stems ultimately from the neural substrates of self-interest or those pertaining to moral judgment, thereby shedding light on a key question concerning human motivation.

Becker and colleagues (2011) suggest that the goal of hierarchical reductionism is not merely to replace concepts from one field with those from another but rather to connect or unify concepts from diverse fields located at different levels of explanation – a process known as consilience. According to Becker and colleagues (2011: 936), consilience is a legitimate and proper goal of science since, "an explanation at one level of abstraction will inevitably lead to questions that are better answered at other levels." Hence, according to this view, hierarchically integrating higher-level descriptions with lower level explanations provides richer and more robust theories. Other management scholars have used this same hierarchical reductionist logic to argue in favour of neuroeconomic analyses of organizational problems (see, e.g., Volk and Kohler, 2012: 523).

In the background to the reductive vision for organizational neuroscience exemplified by Becker and colleagues' analysis lie fundamental differences of opinion regarding how the brain functions. One school of thought, the more traditional view, dating back to the classic work of Lashley (1930), is predicated on the notion of localization of function. Based on this notion, neuroscientists seek to identify particular brain regions and neural structures associated with particular behavioral functions. For example, the occipital lobes enable visual processing, whereas the primary function of the temporal lobes is to process auditory stimuli. Based on this assumption, hierarchical reductionism views the central nervous system as a hierarchical system, whereby certain neuronal structures predominate invariantly over others in the planning and execution of all aspects of human behavior.

An alternative vision, however, borne of contemporary advances in neuroimaging, has challenged the primacy of localization of function, demonstrating that in order to execute particular actions people draw upon multiple neural systems in concert. Mounting evidence informed by advances in neuroimaging, centred on functional magnetic resonance imaging (fMRI), indicates that at any given moment multiple structures and systems of the nervous system contribute to thought and action (Lieberman, 2007). These more recent developments imply that skilled performance emerges from an orchestrated interplay of multiple regions and structures dispersed across the brain as a whole (Lieberman, 2000), analogous to the way in which leadership and coordination processes operate in organic organizations. The emergentist principle that the interaction between distributed neural components produces properties of cognition and mind that are irreducible to those components (see, e.g., Bunge, 1977) is essential to current understanding of a wide range of cognitive phenomena, from mental representation (Barsalou, 1999; Rumelhart et al., 1986) and working memory (Postle, 2006) to consciousness itself (Damasio, 2010). These developments problematize hierarchical reduction as the basis for organizational neuroscience.[1]

The legacy of (strong) hierarchical reductionist localization of function is epitomized in Mintzberg's (1976) well-known *Harvard Business Review* article, 'Planning on the left side and managing on the right', which sought to reduce logical analysis capabilities to the brain's left hemisphere and intuitive and emotional capabilities to its right hemisphere. The idea that the left or right hemispheres dominate particular cognitive tasks – the lateralization of function hypothesis that informed the Nobel Prize winning split-brain studies of Gazzinaga and Sperry –was over-extended by Mintzberg (1976), among others, to the realms of decision making, as has become clear in the wake of more recent studies using fMRI showing that intuition, insight, creativity and related processes arise from a complex interplay of cortical and subcortical neural structures that integrate somatic (i.e. bodily) and cognitive-affective signals, including messages from the viscera (Damasio, 2010; Lieberman, 2000; Satpute and Lieberman, 2006). As observed by a number of commentators (e.g. Akinci and Sadler-Smith,

[1] Note, however, that even the early pioneers of localization of function research acknowledged that the neural structures implicated in particular activities operate interdependently. For example, in his 1929 Presidential Address to the American Psychological Association, Lashley observed "I need scarcely point out the difficulties encountered by the older doctrine of cerebral localization. It expresses the fact that destruction of definite areas results in definite symptoms and the probable inference that these different parts have diverse functions, but it has given us no insight into the manner in which the areas or centers exercise their functions or the way in which they influence one another." (Lashley, 1930: 24)

2012; Dane and Pratt, 2007; Gazziniga, 2006; Hodgkinson and Healey, 2011; Hodgkinson and Sadler-Smith, 2003), the earlier oversimplification of lateralization of function has resulted in questionable management theory and ill-conceived assessment tools.

Limitations of the Anti-Reductionism Critique of Organizational Neuroscience

By aligning itself with hierarchical reductionism, organizational neuroscience locates itself in hotly contested philosophical territory. Following Feyerabend’s (1962) essay on incommensurability in the reduction of scientific theories, social theory has tended to reserve the term reductionism for pejorative use (Sayer, 2010). In organization theory, hostility toward reductionism has long been evident in debates over agency and structure, in which deterministic and structuralist organization theorists oppose biological reductionism, psychologism, and behavioral individualism by positing social structures and processes as independent causal forces constraining organizational actors (Blau, 1974; DiMaggio and Powell, 1983; Donaldson, 1996). It is thus unsurprising that some scholars have begun to question the reductionist ethos of organizational neuroscience. In a notable recent anti-reductionist critique, Lindebaum and Zundel (2013) have sought to land a decisive pre-emptive strike against any attempts to use neuropsychological theory and methods to study organizational activities.

Lindebaum and Zundel (2013) contend that organizational neuroscience is bound to fail due to established problems associated with each of three specific types of reduction, namely: theoretical, constitutive, and explanatory reduction. They maintain that progressing organizational neuroscience via theoretical reduction – explaining a higher-level theory in terms of a lower-level one – is logically impossible because MOS theories and neuropsychological theories use qualitatively disparate terminology and logics to describe phenomena and their underlying mechanisms. They argue, for instance, that MOS and neuropsychology attach non-equivalent meanings to the concept of ‘implicit’, making it impossible to connect mirror neurons to tacit behavior via implicit attitudes, in the way suggested by Becker and colleagues (2011).[2]

Lindebaum and Zundel maintain that constitutive reduction – assuming that higher-level social phenomena are, in essence, ontologically indistinct from lower-level phenomena – is equally problematic. For instance, they contend that because organizational phenomena such as leadership are inherently relational and social they are not composed of neuroanotomical structures or neurochemical processes in the same way that atoms are composed of protons, electrons and neutrons.

Finally, Lindebaum and Zundel see no value in explanatory reduction, which entails using lower level entities to explain higher-level entities in a more metaphorical sense; for instance, using patterns or properties observed at the neurological level to describe features at the cognitive or behavioral level. Highlighting the fact multiple brain processes underpin a given psychological state, the 'multiple realization problem', Lindebaum and Zundel imply that explanatory reduction is problematic because researchers cannot be sure which neurological features correspond to a given action.

Lindebaum and Zundel's (2013) critique provides a detailed specification of the problems with the reductionist approach and provides a timely warning. However, their analysis misses a larger point: classical reductionism is not the only vehicle for linking neuroscience and MOS. Lindebaum and Zundel's analysis uses dated philosophical devices that contemporary philosophy of science has countered, not least through advances in critical

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[2] The supposed lack of 'fit' between the terminologies and logics of organizational and neuroscientific theories is not as great as Lindebaum and Zundel imply. For instance, several leadership theorists imbue the concept of 'implicit' with a meaning corresponding to the meaning invoked by social cognitive neuroscientists, as do most theorists of cognition in organizations more generally (see, e.g., Hodgkinson and Healey, 2008a). By way of illustration, one influential neuroscientific study defined implicit attitudes as "automatic evaluation [that] by definition occurs without intention" (Cunningham et al., 2004: 1718). Using an equivalent conception, Leavitt and colleagues (2011: 673) recently studied how implicit attitudes – "cognitive processes that often occur outside of awareness" – towards supervisors influenced followers' behavior. Indeed, research on leader cognition has long discussed implicit phenomenon in terms similar to those used by social cognitive neuroscientists, epitomized by work on implicit leadership theories (Epitropaki and Martin, 2005; Lord and Maher, 1991) and implicit schemas (Lord and Emrich, 2000).

realism. In this sense, denying the relevance of neuroscience for MOS by problematizing psychoneural reductionism constitutes something of a sleight of hand. The countervailing argument we develop below is that, although hierarchical reductionism is untenable, the anti-reductionist denial of neuroscience is too strong, leaving MOS scholars at a dead end and divorcing them from a potentially important source of insight into the generative mechanisms of behavior in the workplace. To break the resulting impasse, we demonstrate next how critical realism provides a viable alternative, non-reductionist vehicle for forging the links required to advance MOS. Critical realism's view of human activity as embedded in a complex ecology of causal forces has been described as "realism without reductionism" (Carolan, 2005: 1) and sets the stage for using socially situated cognition to connect neuroscience with MOS.

A Critical Realist Basis for Linking Neuroscience with MOS

The remainder of this article builds on a line of philosophical inquiry that we have been developing over a number of years to advance MOS as a critical realist science of design (Hodgkinson, 2013; Hodgkinson and Healey, 2008b; Hodgkinson and Rousseau, 2009; Hodgkinson and Starkey, 2011; Hodgkinson and Starkey, 2012;).[3] Originating largely out of the UK in the 1970s and 1980s (Bhaskar, 1975; Harre, 1972; Keat and Urry, 1975), critical realism exists in the space between objectivism and (radical) social constructionism. In the wake of its spreading intellectual influence across the social sciences, MOS scholars are positing increasingly critical realism as a foundation for moving beyond the paradigm

[3] Following Herbert Simon's (1969) classic treatise, *The Sciences of the Artificial,* we have found it helpful to liken MOS to engineering in the physical sciences and medicine in the biological sciences (see also Denyer, Tranfield, & Van Aken, 2008; Pandza & Thorpe, 2010; Tranfield & Starkey, 1998). As argued some 16 years ago by Tranfield and Starkey (1998), the normative implication of this analogy is that the overarching concern of MOS scholarship should be the general (engineering) problem of design — how to create organizations and systems of management that are a better fit for purpose than those we have currently. Doing so demands that the field should aspire to be transdisciplinary and problem-led. Recently, Hodgkinson and Starkey (2011, 2012) have argued the case for expanding the horizons of this design science ethos, by adopting a critical realist philosophy (Bhaskar, 1978, 1979), to move it beyond Simon's (1969) positivistic conception (see also Hodgkinson, 2013; Hodgkinson & Healey, 2008b; Hodgkinson & Rousseau, 2009).

wars between positivism and post-positivist relativism (Fleetwood and Ackroyd, 2004; Miller and Tsang, 2011; Tsang and Kwan, 1999; Reid, 2001).

Bhaskar (1975, 1989, 1998, 2011) has provided the most comprehensive statement of critical realism. Its defining feature is the insistence on an independent material reality, but also a denial of direct correspondence between knowledge claims about that material reality and reality itself. To this end, Bhaskar (1975) distinguished between the intransitive objects of knowledge, which exist independently from human conception (e.g. light, mercury, neurons, and so on) and the transitive objects of knowledge produced through such conception, which are facts, theories, paradigms, models and the like. Building on this distinction, Bhaskar (1975) articulates a stratified account of reality that distinguishes: (i) the 'real' world of causal powers, which contains deep structures and generative mechanisms that give rise to actual events, (ii) the actual, namely the flow of events produced either as natural states of affairs or under controlled conditions, and (iii) the empirical, events known directly or indirectly through observation and experience. By asserting the independence of reality, actuality and the empirical, Bhaskar (1975) avoids the epistemic fallacy of conflating ontology with epistemology. More pragmatically, his separation of these three strata allows for the co-existence of competing knowledge claims and the inevitable fallibility of those claims in terms of their veracity. However, since certain claims have greater verisimilitude than others (i.e. some empirical observations are closer to the actual and real than others), science can progress only through critiques of relative explanatory value, rather than through a linear progression toward *the* truth, a process known as retroduction.

A notable feature of critical realism is that it sees epistemological common ground for the physical and social sciences, even while maintaining a unique ontology for the transitive objects of social scientific study. This epistemological compatibility is evident in Bhaskar's (1975: 16) conversion of transcendental realism ("a law-governed world independent of man") in the physical sciences into critical naturalism in the social sciences. According to Bhaskar (1978: 22), critical naturalism concerns an "extra-conceptual reality ... which is really generative of social life and yet unavailable to direct inspection by the senses." Critical realism's status as a meta-theory, positing common explanatory mechanisms across the sciences, thus provides an ideal means to bridge social neuroscience and MOS.

Emergent powers materialism

For the critical realist, human behavior has a real physical existence free of agents' conceptions of that behavior, even if empirical access to the real structures and mechanisms at work is only ever indirect. It is precisely the material nature of the human physical condition that enables this independence; specifically, the fact that persons are material things comprising cells, brains, and bodies (including neurophysiology) and are characterized by their biological basis. To overlook this material basis is to lose sight of the essence of human action. As Bhaskar (1978: 15) notes, social theory should take for granted that:

> persons are material things with a degree of neuro-physiological complexity which enables them not just, like the higher animals, to initiate changes in a purposeful way, to monitor and control their performances, but to monitor the monitoring of these performances and to be capable of a commentary upon them.

As Bhaskar points out, it is by recognizing the human ability to act back upon and transform their own physical states and behavior that we can be sure that body and mind are causally related but also distinct. In the context of organizational life, it is precisely the bio-material human constitution that enables organizational actors to initiate purposeful change in their internal and external environments, reflect on their own and others' actions, and ultimately to regulate their own performance (Bandura, 1991). A further reminder of the human physical condition is that affect (i.e. feeling) pervades the capacities for agency and self-awareness, such that agents attach meaning to the social world as feeling organisms (Bhaskar, 1998). These and other human powers such as speech and language are both ontogenetically rooted in organism development and phylogenetically rooted in biological and cultural evolution. Given that conscious and goal directed agents are situated in pre-existing social contexts, simultaneously mobilizing and being shaped by social structures, human activity is an "irreducibly bio-social product" (Bhaskar, 1998: 411).

An important corollary of human materiality is the asymmetrical ontological relationship between the biophysical realm and the social realm; specifically, the social cannot exist without the biophysical but the biophysical can exist without the social (Bhaskar, 1998; Carolan, 2005). This asymmetry leads naturally to questions concerning the direction of causality between the biophysical and the social. However, the critical realist stance on this matter contrasts sharply with the reductionist position exemplified in organizational neuroscience. As observed earlier, Becker and colleagues' (2011) hierarchical reductionism equates mental states with brain states and thus assumes strictly bottom-up causality. This reductionist approach thus aligns with *central state materialism,* the position that mental states are equivalent to physical states and those physical states are fully determined by underlying natural laws (Green, 1981).

Bhaskar (1998) outlines *emergent powers materialism* as the alternative to central state materialism (see also Kim, 1999; Rueger, 2000). Emergent powers materialism is characterized by rootedness and emergence. Rootedness is the tenet that higher-level features grow from origins that are more basic; in the case of human systems, these origins are biophysical roots. Emergence is the principle that higher-level phenomena such as mind emerge from, but are irreducible to, matter. Mind is said to be an emergent power of matter (Bhaskar, 1998); the social emerges from, but does not depend fully on, the material.

Two features of rootedness and emergence hold implications for the neuroscientific analysis of organizational behavior. First, the processes of emergence – specifically complex interactions between multiple components, potentially operating at different levels – ensure that higher-level phenomena ultimately possess properties that are independent of, and cannot be predicted or even explained by, their lower level roots (Kim, 1992; Wimsatt, 2000). As Kim (1992) notes, we may know all about the neurobiological and physiochemical processes of a given psychological process, yet have no idea what sensory qualities emerge from it, unless we have already observed certain sensations emerge from an identical set of conditions. Nonetheless, those physical roots play a key contributory role.

Second, once higher-level phenomena emerge in distinct forms, they exert a recursive influence upon the operation of the lower level mechanisms that gave rise to them, acting as constraints. In this way, higher-order psychological states emerge out of biological and neurophysiological processes, states that in turn recursively shape subsequent neurophysiological activities. By way of illustration, goals, needs and perceptions are mental events that emerge from activity in particular brain regions but, once developed, those higher-level mental events subsequently shape how the brain behaves. For instance, although social agents use mirror neurons to monitor one another's behavior (Rizzolatti and Craighero, 2004), it is perceptions (i.e. attitudes, stereotypes) and acts of interpersonal communication (e.g. prompting from those being monitored) that determine when such monitoring takes place, continues, and stops (cf. Becker et al., 2011).

Dual control of organizational action. Emergence builds on Polanyi's (1968) likening of human biological systems to manmade machines, which highlights that both are under the dual control of higher-level structures and lower level laws of nature. In human biological systems, higher level structures (e.g. organs serving particular purposes) serve as boundary conditions that harness the biophysical and biochemical processes that enable specific functions. Similarly, a machine's higher-level design principles harness the lower level (i.e. electro-physical) processes on which it relies for functioning. In both cases, it is impossible to explain the workings of the system in terms of its lower level features alone, because higher level structures control how those lower features are organized and thus control how the system as a whole functions. Hence, under dual-control, higher level features serve as boundary conditions for lower level mechanisms, the former shaping the manifestation and deployment of the latter. Bhaskar (2008) extends the logic of dual-control to human social systems. For instance, conversation, itself arising from language, constrains in turn the use and development of speech. In economic systems, technologies give rise to new markets that subsequently shape how those technologies are used, whereupon the use of technology determines the conditions under which certain physical laws operate. Given dual-control, the workings of complex systems are irreducible to lower level laws.

Although complex systems are not fully *determined* by lower level laws, they are nevertheless *bound* by them. As Polanyi noted, because higher level features harness (i.e. make use of) lower level processes, those processes still set the boundary conditions for higher level features. For instance, a machine cannot operate beyond the boundary conditions of the laws of physics and chemistry. Analogously, Polanyi (1968: 1312) argued that: “the mind harnesses neurophysiological mechanisms and is not determined by them ... we can see then that, though rooted in the body, the mind is free in its actions.”

Predicated on this dual-control logic, MOS scholars should not ask questions concerning which neuropsychological processes cause or determine particular behavioral phenomena. Rather, they should ask which neuropsychological features higher-level individual and socio-organizational processes draw upon or *harness* in the execution of particular significant organizational activities. There is a subtle but important difference between these two approaches. The difference is between assuming that the higher level functions of cognitive systems in social organizations *harness or make use of* lower level (i.e. neurological) processes and assuming that those processes *determine* the behavior of the wider systems in question.

Emotional roots of decision. To illustrate the emergence of organizational activity within neurophysiological boundaries, consider the case of how affect (i.e. feelings and emotions) bounds organizational decision making. Individuals and groups draw on affect to make organizational decisions; decision makers use feelings and emotions to variously guide attention to the external environment, change or reinforce mental representations, and impel action toward alternative courses of action (Hodgkinson and Healey, 2011). Affect sets the boundary conditions for organizational decisions because: (i) it seems unlikely that important organizational decisions can occur without invoking human feelings and (ii) specific emotions shape the social processes of decision making (Andrade and Ariely, 2009; Barsade and Gibson, 2007; Janis and Mann, 1977; Seo and Barrett, 2007; Wong et al., 2006). This is not to say that either decisions or emotions themselves can be reduced wholly to neurochemical processes. Rather, from a critical realist standpoint, emotions and decisions both emerge from interactions among neural, somatic, cognitive, linguistic and social forces – but their basic nature is partly rooted in the human physiological condition (Harre, 2009; March and Simon, 1993).

The example of affect in organizational decision processes is noteworthy because it illustrates the real value of neuroscience for understanding managerial and organizational phenomena in general. That is, without appreciation of the embodied nature of human cognition, we run the risk of perpetuating models of organizational activity that run contrary to contemporary understanding of human nature. Computational models of human thinking and action based purely on ‘cold’ cognition still predominate in management and organization theory (Hodgkinson and Healey, 2008a). Continuing to build MOS theory on computational models that are themselves based on the experimental psychology of the mid-twentieth century is problematic because contemporary psychological science suggests that many aspects of behavior once thought as the preserve of cold cognition in fact rely heavily on affective mechanisms. The turn to embrace hot cognition – informed by neuroscientific studies of the mechanisms recruited by behavioral phenomena such as attention, decision, and sensemaking – necessitates a change in MOS theories that make assumptions concerning human cognition (Hodgkinson and Healey, 2011). If behavioral plausibility is a desirable criterion for management and organization theory (Gavetti et al., 2007), then social neuroscience has an important role to play in defining what is behaviorally plausible.

Ecological Embeddedness: Organizational Neuroscience and Socially Situated Cognition

Although, as demonstrated above, emergence obviates the need for hierarchical reductionism, it is still vital to choose carefully the conceptual apparatus used to incorporate the neurobiological roots of managerial and organizational activities. According to Lindebaum and Zundel (2013), one solution to the alleged "lack of 'fit' between the terminologies and logics of organizational and neuroscientific theories" is to construct 'bridge laws' (Nagel, 1961); that is, laws that provide logical connections between concepts established in the two fields in question. In the present context, this approach involves creating bridge laws (B) that connect organizational concepts (O) to neuroscientific concepts (N) in a hierarchically linear sequence (i.e. N$\rightarrow$B$\rightarrow$O). Viewed thus, bridge laws are mediating devices designed to translate. They build relations between concepts while preserving the idiosyncratic meanings attached to those concepts in their originating fields. However, as Lindebaum and Zundel illustrate, creating such bridge laws will be practically messy and logically difficult.

An alternative approach is to adopt an overarching theoretical framework that will in the longer term allow for closer integration of concepts describing higher-level (i.e. management and organization) phenomena and those describing lower-level (i.e. neuropsychological) mechanisms. This approach is akin to arguments developed by Hooker (1981a, 1981b) and Kim (1998). Both writers point out that in many cases inter-theoretic syntheses proceed not by *deriving* a target theory from a source theory but by using the source theory to produce a 'corrected analogue' of the target theory, a process that imbues the corrected analogue with greater explanatory power.

Unlike inter-theoretic *reduction*, however, where the concepts and rules of a lower-level source theory (i.e. neuroscientific theory) re-formulate the target theory (i.e. organization theory), we suggest that the influence should flow both ways. Our approach is to ask, in the spirit of critical realism, two questions: (i) what must neural mechanisms be like for characteristic organizational activity to be possible and (ii) what must organizational activity be like for neural mechanisms to be possible? Answering these questions promises to yield not only changes to our target theories of organizational behavior, but also changes to the way we view source theories of neural functioning (cf. Senior et al., 2010). Specifically, we submit that socially situated cognition can be used as a framework to model corrected analogues of both neurological mechanisms (N_1) and organizational processes (O_1) as components of organizational cognitive systems (C), i.e. $\{N_{1,} O_1\} \in C$.

As described by Smith and Semin (2004), four principles characterize socially situated cognition (SSC):[4]

1. Cognition is for adaptive action: it serves to produce future actions and is not an abstract enterprise designed for its own ends. Hence, the primary purpose of cognitive entities such as attitudes is to guide future actions;
2. Cognition is socially situated: it emerges from the dynamic interaction between agents, tasks, and environments. This view stands in contrast to the mentalistic assumption that cognition is 'in the head' and can be studied irrespective of context. By way of illustration, rather than providing mere background the physical

[4] There are various theories of situated cognition and the general approach embraces work on situated action (Glenberg, 1997), grounded cognition (Barsalou, 2008) and embodied cognition (Wilson, 2002). We use the term socially situated cognition as an umbrella term to encapsulate principles of situatedness, grounding, and embodiment.

environment provides resources integral to human cognition, evident in the way we offload mental tasks to external tools (Hutchins, 1995) and rely on object affordances to guide action (Norman, 1988);

3. Cognition is embodied: body and mind are tightly linked (Clark, 1997; Niedenthal, 2007; Wilson, 2002). In particular, symbolic cognition is not divorced from perception but is grounded in multiple sensory modalities (Barsalou, 1999, 2008), drawing on the systems responsible for perception (i.e. vision, audition), bodily movement (i.e. sensorimotor functions) and introspection (i.e. feelings and mental states);
4. Cognition is distributed: it emerges across brains and the environment, through the use of artifacts and tools, and across social agents, via communication and other group activities.

The principles of SSC hold, above all else, that cognition is embedded in an extended system that unites brain, body, and mind with the social and material environment. In a distributed cognitive system, "adaptive cognition involves perceptual–motor loops that pass through the environment" (Smith and Semin, 2007: 134), rather than being something that is implemented solely by intra-individual processes.

To illustrate, consider again the case of mirror neurons. It seems that understanding social stimuli depends on our ability to simulate actions and feelings in our own bodies. Studies show that when an agent observes another engaging in a goal-directed action (e.g. grasping an object) their motor cortex is activated, even when this activation does not translate into action on their own part (Rizzolatti and Craighero, 2004). Similar effects occur when understanding emotions: to understand others' pain we simulate our own pain, via activation of a neural network corresponding to that feeling (Decety and Grezes, 2006). Crucially, inhibiting the motor movements involved in the bodily expression of emotion interferes with agents' ability to both experience emotion personally and to comprehend emotion experienced by significant others (Niedenthal, 2007). Hence, empathizing with others depends on bodily capabilities as well as brain processes. It is in this sense that the cognitive mechanisms for action pass through the environment, in this case the bodily environment, as well as the brain. Contrary to the hierarchical reductionist approach to organizational neuroscience, the ability to relate to others cannot be analyzed validly by confining attention to the activation of specific brain regions.

Brain, mind and body in adaptive organizational systems. If neuropsychological processes are not the ultimate determinants of organizational behavior, then what role *might* they play? The answer from a SSC perspective is that the brain is but one mechanism, albeit a directing one, responsible for the functioning of embedded cognitive systems. As Clark (2008: 122) observes, although brain activity is never sufficient for the existence of a given cognitive state, that activity is still part of the machinery that implements the state in question:

> It is indeed the biological brain (or perhaps some of its subsystems) that is in the driver's seat. That is to say, it is indeed some neurally based process of recruitment that ... turns out to be so pointedly unbiased regarding the use of inner versus outer circuits, storage, and operations. But once such an organization is in place, it is the flow and transformation of information in (what is often) an extended, distributed system that provides the machinery of ongoing thought and reason.

Adopting the neurocentric view that all cognition occurs in the brain's structures and processes, we lose sight not only of the system's other contributing components (e.g. bodily, artifactual, social) but also of how those components combine in the execution of skilled tasks. But straying too far in the opposite direction, by ignoring the role of neuropsychological mechanisms in organizations, omits a crucial part of their machinery.

From a SSC perspective, Clark (1997: 130) suggests that human cognitive systems possess emergent properties at two main levels. First, internally emergent features result from the interaction of multiple inner sources of variation; for example, specialized but distributed brain regions produce higher-level cognitive functions that are more than the sum of their components. Hence, the reflexive (i.e. implicit and automatic) cognitive processes described by Lieberman (2007) emerge from interactions among various subcortical and cortical neural regions.

Second, behaviorally emergent features result from interactions between the whole organism and the environment and are inexplicable without reference to systems level factors that shape collective properties. Hence, the failure to understand internal and behavioral emergence provides an incomplete specification of complex human systems.

Viewing organizational behavior as a reflection of systems within systems provides significant explanatory power. In this view, the brain is one system whose properties emerge from interactions among complex components, including various neural structures and processes, bodily feedback and environmental stimulus inputs. Likewise, the wider organizational cognitive system emerges from interactions among various internal (including the brain system) and external (artifacts, social situations, environmental features) components. By way of illustration, group information processing systems (Hinsz et al., 1997) arise from interactions among individuals comprising their own cognitive systems. In turn, those interactions depend on social identities that are inherently relational. Moreover, local environmental conditions (e.g. cultural norms, power structures) constrain interpersonal interaction. To no small extent, the system that warrants closest attention depends on the level of analysis closest to the behavior to be explained (Hackman, 2003). But in adopting such a focus, we should not lose sight of the embeddedness of a given system in relation to the more micro and macro systems surrounding it.

Revisiting the entrepreneurial brain. It is instructive to contrast more explicitly the SSC view of the brain's role in organizational life with the reductive alternative adopted by organizational neuroscience's advocates. Entrepreneurship provides an interesting case. One way to use neuroscience in this context is to examine the extent to which and in what ways entrepreneurs' brains differ from those of managers and/or other groups of organizational actors, for example in terms of their sensitivity to risk (Becker et al., 2011; Nicolaou et al., 2008a, 2008b; Senior et al., 2011). The assumption underpinning this approach is that entrepreneurs possess distinctive neuroanatomical features – concerning the dopaminergic regions of the brain's reward centres – that hardwires them for the kind of 'functional impulsivity' (Lawrence et al., 2008) required for risk seeking behavior when facing high-stakes (i.e. affect-laden) investment prospects. The natural conclusions from adopting this approach are that effective entrepreneurs can be identified based on the risk-proneness of their brains (Becker et al., 2011) and that stimulating the appropriate neurochemistry (e.g. with drugs) can enhance entrepreneurial behavior (Lawrence et al., 2008). The overriding assumption of this, the neurocentric view is that entrepreneurial capability resides in the brain.

From a SSC perspective, entrepreneurial capability is much broader, emerging from a cognitive system that draws on brain, body, and environment and extends to the activities of multiple actors. One recent line of inquiry consonant with this constructive alternative emphasizes that entrepreneurs rely on communication to legitimate themselves and their ventures and that hand and bodily gestures are integral to this legitimation process (Cornelissen and Clarke, 2010; Clarke and Cornelissen, 2011). This research suggests that gestures do not simply express underlying thoughts; they also convey information not contained in speech. For instance, gestures communicate perceptual-motor information about objects and activities (e.g. simulating a motion path to illustrate a business moving forward), thereby allowing agents to ground abstract concepts in physical experience, thus improving listeners' understanding (Cook and Tanenhaus, 2009). In addition, gestures play an active role in cognition. Studies show that agents off-load tasks to gesture in order to lighten cognitive demands. For instance, gesturing while learning new ideas helps people retain knowledge, whereas impeding the ability to gesture reduces that ability (Goldin-Meadow, 1999; Goldin-Meadow et al., 2001). Related studies show that gesturing also shapes the representation of tasks. For instance, when people use particular gestures to explain a problem those gestures influence the way they approach that problem subsequently, suggesting that the way they mentally represented the task depends on the gestures used (Beilock and Goldin-Meadow, 2010). Evidence suggests that similar mechanisms are at play when entrepreneurs use gesture to gain support from investors (Cornelissen et al., 2012).

We are not simply pointing out here that entrepreneurship is a social process rather than a neuropsychological one. Instead, we are arguing that neuropsychological processes are a constitutive mechanism of social processes in general. As Clark (2008: 125) observes, gestures and actions are not the mere expressions of fully formed neural processes; rather, they are "part and parcel of a coupled neural-bodily unfolding that is itself usefully seen as an organismically extended process of thought". This perspective requires a more recursive understanding of the relationship between brain, body and action in organizations. Our overriding message is that attempts to study managerial and organizational phenomena neuroscientifically should be contextualized appropriately, based on the principle that neural activity, mind, body, and social processes form an integrated system. Conceived thus, it makes little sense to isolate the virtues of individual neuroanatomical components. However, understanding how neural systems mediate the exchange of information passing through bodily and social loops might well prove illuminating for MOS research.

Downward Causation in the Neuroscientific Analysis of Organizations

As we have seen, analyzing the neurological mechanisms of management and organization requires a model of causation that avoids the trap of positing neural mechanisms as primal causes but which also moves beyond the strong anti-reductionist thesis that lower-level (i.e. brain) processes bear little relation to social phenomena. Critical realism and SSC provide such a model, assuming that causation is multidirectional and generative rather than unidirectional and invariant.

In marked contrast with naive empiricist positivism, which assumes that what is observed is what is important, critical realism focuses on the unobservable generative mechanisms (social, cultural and biological) necessary for a particular turn of events to occur, which are themselves a complex outcome of structure and agency (Bhaskar, 1975). Events occur when actors mobilize the resources at their disposal in a given context to shape change. According to Bhaskar (1975: 3), the generative mechanisms of events are "the ways of acting of things" that occur in the domain of the real. For human activity, generative mechanisms concern material elements but also extend to social structures and forms, "an ensemble of structures, practices and conventions" (Bhaskar, 1978: 12), which individuals and groups reproduce and transform via their motivated actions. Given that human actions can change social systems but are recursively shaped by them, all social systems are necessarily open systems, in which: "invariant empirical regularities do not obtain" (Bhaskar, 1978: 18). Moreover, given the hidden complexities pertaining to the generative mechanisms at play, as argued by Bhaskar (1975), the social sciences can only operate by 'retroduction', the theoretical reconstruction of plausible explanations of the conditions and mechanisms necessary for the events at hand to have occurred.

Given that the social structures and processes that agents co-create constrain their actions, the influence of causal forces cannot be unidirectional, i.e. flowing only from the individual to the social. For this reason, models of social activity must account for downward causation as well as upward causation. Whereas upward causation concerns the bottom-up influence of lower level entities on higher-level ones – for example, positing neuronal processes as causes of organizational behavior – downward causation emphasizes constraints in the opposite direction.

Campbell (1990: 180) illustrates downward causation through natural selection in biological evolution, where “the laws of the higher level selective system determine in part the distribution of lower level events and substances.” Similarly in social systems, once aggregate processes emerge from lower level mechanisms they become causal forces with the same legitimacy and power as lower level factors (Bickhard and Campbell, 2000). Several recent studies have demonstrated the top-down influence of social structures on the operation of neurological circuits. For instance, Spitzer and colleagues (2007) found that situations where the violation of social norms can lead to punishment influenced distinctive neural networks leading to increased norm compliance.

The emergence of such higher-level processes and structures ensures that “the system as a whole gains a broader causal repertoire” (Murphy and Brown, 2007: 89). Viewed from this perspective, although neuroanatomical structures and processes may be homogenous across individuals (Becker et al., 2011) heterogeneity in organizational structures and processes creates considerable variation in behavior, because such structures and processes exert distinct influences on neural systems.

How organizations influence the brain. The legitimacy of higher-level causal emergents in complex organizational systems suggests an alternative research agenda to that envisaged by bottom up (i.e. hierarchically reductive) accounts of organizational neuroscience. Rather than focusing on how the brain causes behavior in organizations, it may be equally valid and valuable to ask how work organizations influence the brain. By way of illustration, one potential line of inquiry is to examine the role of organizational routines and systems in variously suppressing and harnessing the lower level neural motivational systems concerning self-interest and impulsiveness. As Postrel and Rumelt (1992) note, an oftenoverlooked purpose of organizational routines and structures (such as hierarchy, supervisory arrangements, rules and policies) is to provide external controls on the human impulses that prevent agents from acting in their own (and often the firm's) long term interests (see also Hodgkinson and Healey, 2011; Teece, 2007). Such impulses include procrastination, reacting angrily, seeking immediate gratification, withdrawal and absenteeism. Postrel and Rumelt (1992) argue that a model of 'impulsive man' is required to explain the range of routines and practices that emerge within and across organizations, a model that diverges from standard economic man (homoeconomius).

Although neuroscientists have already begun to identify the neural substrates of impulsiveness using economic games (McClure et al., 2004), if organizational neuroscience is to provide a richer and more useful understanding of impulse control, it must surely move beyond scanning for activation in the neural substrates of self-interest during contrived tasks. Indeed, understanding impulse control and emotion regulation in organizations requires a broader, more socially situated approach. In order to explain why some organizations are more effective than others in regulating and harnessing impulses, we need to understand how the neurological processes of self-interest and impulsiveness *mediate* between organizations' distinctive social, artifactual and cultural features and the expression of impulsive behavior. In this view, the machinery of motivated activity and emotion regulation involves the transmission of information from external artifacts (e.g. norms, routines, social cues) to intrapersonal neural systems and executive cognitive control systems, and onward to the restrained or indulgent actions of agents. Viewed thus, the architecture of work organizations is configured so that impulse control and emotion regulation are off-loaded to extra-personal processes and structures (e.g. norms, routines, hierarchies). Hence, agents actively create the external structures that constrain their ongoing processes of thinking and feeling (James, 1989; Morris and Feldman, 1996).

Corporate corruption scandals such as the recent, highly publicized cases of Enron and Lehman Brothers provide an interesting basis for illustrating the foregoing principles in action. One way to explain complex cases such as these is to assume that something specific to the underlying neurology of the key individuals involved was instrumental to the deceit and other dysfunctions displayed by them. Supporting this thesis, various studies point to abnormalities in cortical and subcortical brain structures among psychopathic individuals (Muller et al., 2003). With this evidence in mind, it takes only a small leap to explain corporate dysfunction and psychopathy by reference to stable neurobiological differences (Babiak and Hare, 2006). Indeed, identifying exceptional neuroanatomical functioning might ultimately help to shed light on why rare individuals and groups are able to act constructively to break through and redefine those pathological organizational cultures and practices that bind in dysfunctional ways the behaviors of many others.

However, in general this neurocentric approach ignores the role that higher-level boundary constraints – specifically organizational culture, group norms, corporate rules, and routines – play variously as triggers, facilitators, suppressors, and regulators of moral cognition (cf. Hannah et al., 2011; Sadler-Smith, 2012; Wang and Murnighan, 2011). From a SSC perspective, higher-level artifacts and processes influence the social signals that the neural system uses, in concert with bodily and other resources, to convert them into motivational states and ultimately actions. This top-down perspective leads naturally to questions of a rather different nature, not least questions concerning the extent to which and in what ways certain types of social norms and routines are more or less effective in regulating destructive impulses, and what processes and practices might help to foster moral judgments and emotions of the sort that might benefit the long-term interests of collectives.

Rather than merely focusing on how the brain's emotion centers drive impulsive behavior in organizations, thereby downplaying the role of higher-level (i.e. extra-personal) causal forces, a socially situated perspective suggests that organizational neuroscientists would benefit from focusing on how organizations influence the neural substrates of motivation and emotion that are generative mechanisms of impulsiveness. This view contrasts sharply with Powell and Puccinelli's (2012) recent claim that neuroimaging technology may prove ultimately more effective than organizational structures and processes (including incentives and routines) as a means of controlling basic human impulses (see also Powell, 2011). Equipped with insights from SSC, this debate concerning how best to gain control of workplace emotions in the service of the greater good becomes an empirical question to be addressed by competitive theory testing. Are external controls (e.g. norms, routines, structures) more or less efficacious than internal controls (e.g. brain technologies, self-regulation strategies) for controlling impulses such as self-opportunism, instant gratification, and deceit? The fact that agents commonly off-load impulse control to external structures and routines could either be a reflection of the functional efficacy of this design feature or a reflection of its architectural simplicity.

Liberatory potential of organizational neuroscience. An understandable concern over the rise of organizational neuroscience is that powerful stakeholders, not least senior managers, might seek to use so-called 'brain technologies' for the neurological modification of employees (Lindebaum, 2013). Research on topics such as innovation and decision making that advocates or practices the use of interventions such as neuropharmacology (Lawrence et al., 2008) or transcranial magnetic stimulation (Knoch et al., 2006) seemingly make this prospect more real. Behind such interventions lies a bottom-up causal logic that legitimizes the enhancement of neurological processes posited as *the* drivers of employee performance.

Despite these concerns, there are other means by which stakeholders might use neuroscience for the *benefit of employees*, based on a top-down causal logic. For instance, neuroscientific methods might be used to assess and monitor the effects of organizations on neurological health. We have known for some time that environmental stressors affect brain and body via the hypothalamus-pituatary-adrenal axis (Johnson et al., 1992) and that job stress elevates blood pressure and serum cortisol levels (Fox et al., 1993). Neuroimaging techniques promise to take this important line of work further. In one recent study, researchers used positron emission tomography to scan the brains of Japanese clerks who had experienced chronic job stress versus low job stress while they performed a non-work-related unlearning task (Ohira et al., 2011). They found that the brains of chronically stressed clerks were less active in the regions associated with goal-directed action, suggesting that chronic job stress can reduce neurological responsiveness outside of the workplace.

In time, neuroscience might help researchers examine whether other organizational stressors such as psychological contract breach (Robinson and Morrison, 2000) exert lasting damage on the human central nervous system, leading not only to performance decrements but also to health problems within and beyond the workplace (cf. Zhao et al., 2007). Such findings would be instructive for health regulators, among other stakeholders, seeking to ameliorate such deleterious effects (cf. Black, 2008). From a more positive angle, researchers might usefully examine how job enrichment programs affect the human nervous system (cf. Hackman and Oldham, 1976). Again, neurological data could provide compelling evidence that might help ultimately to re-humanize the workplace.

Implications for future research

Bringing together critical realism and socially situated cognition, we have begun to outline a philosophical and theoretical approach that MOS researchers can use to build on the insights of social neuroscience. Our analysis demonstrates that replacing the central state materialism of organizational neuroscience with emergent powers materialism (Bhaskar, 1998) affords an upwardly-constraining role for neuropsychological roots, while avoiding over-privileging the causal power of the brain in human activity.

Our analysis of emergence under the dual-control of lower (e.g. neuropsychological) and higher (e.g. conscious agent, group and organizational) boundary conditions renders untenable the idea that research should prioritize neural processes as the primary determinants of organizational behavior (cf. Becker and Cropanzano, 2010; Becker et al., 2011; Lee et al., 2012; Senior et al., 2011; Volk and Kohler, 2012). Equally untenable, however, is Lindebaum and Zundel's (2013) conclusion that because socially complex organizational phenomenon cannot be reduced to the neuroscientific level it is impossible to connect logically neuroscience with MOS. Although neurological processes do not fully determine organizational behavior, these processes – in concert with bodily and other extra-cranial capacities – set important lower-level boundary conditions that impose strong constraints upon what is and is not possible. We have seen, for instance, that decision making requires neurobiological emotion and economic cooperation is rooted in important neural mechanisms that convert social signals into action. Hence, explaining organizational behavior by ignoring neurophysiological materiality is to divorce organizations from the lower level boundary conditions that shape their actuality.

Like others (e.g. Cropanzano and Becker, 2013; Lindebaum and Zundel, 2013), we see dangers inherent in organizational neuroscience. However, our analysis draws attention to dangers of a different kind. Our primary concern is that organizational neuroscience might lead us further down the path of assuming that the effective performance of work tasks depends primarily on neural capacities located *inside* individuals. Adopting the SSC framework we have outlined can help MOS scholars avoid this mistake. As we have seen, SSC posits that performing complex work tasks such as planning or deciding relies on representations distributed across individuals and externalized in artifacts outside the brain. Such off-loading removes the burden of representation and computation from individuals, placing it instead on the system as a whole, which has far greater cognitive capacity. Socially situated cognition thus reminds us that organizational cognitive capabilities are not merely the sum of individual neural processes.

Our framework for utilizing the insights of social neuroscience in MOS research requires a research programme examining organizations and organizational behavior as a reflection of embodied but also socially situated cognition. Such a programme would seem to require a commitment to certain basic principles; below we outline three such principles and sketch examples of the types of studies that they might inspire.

First and foremost is the commitment to recognizing brain, body and social structure as interlocked components of open organizational systems. This commitment moves us away from viewing the individual brain as an isolated entity or closed system. Viewing the brain not as chief cause but as a central regulatory organ (Cacioppo, Berntson and Decety, 2012) can help us understand at a deeper level the nature and functions of the organizational systems that individuals build to support their economic activity. For instance, the emotional and bio-regulatory processes of decision making (Bechara, Damasio and Damasio 2000) seem to require systems, cultures and routines that provide specific types of support for organizational decisions. Future research might examine how organizations evolve different social and technological structures that support or impede the specific needs of the emotional brain in decision making (Hodgkinson and Healey, 2011). The development of low cost, minimally invasive and portable brain scanning equipment capable of monitoring emotional and self-regulatory responses brings such usage within reach (e.g. Debeneur et al., 2012).

A second principle for a SSC agenda is to focus on how neural, bodily, technological and social mechanisms interact at various levels to constitute emergent organizational behaviors. Initial research on situated cognition in organizations hints at the possibilities of using neuroscience for this purpose. Elsbach and colleagues (2005) argued that features of the organizational context such as the cultural, artifactual, physical and socio-dynamic shape emergent cognitive phenomena such as problem framings and collective mindsets. Neuroscience can enrich this mode of analysis by examining, for instance, the types of organizational norms, routines and group dynamics required for harnessing the emotional and cognitive processes that influence moral conduct in organizations. In this connection, the cortical and subcortical neurological mechanisms underlying those processes (see Moll et al., 2005) become legitimate interests not as primal causes but as mediators between situational features of the organization and moral cognition and behaviour that provide important clues regarding the effectiveness of different situational features as facilitators of moral behavior.

A third principle involves maintaining the commitment to the social and distributed nature of cognition. Initial forays into organizational neuroscience focus on one brain at a time. Recent technological developments (e.g. Spiegelhalder et al., 2014) suggest that it will soon be possible for researchers to scan the brains of multiple actors engaged in wide variety of social activities, including those of the workplace. Such methods will open the doors for researchers to examine the inter-individual synchronization of neurological, cognitive and affective functioning. Such methods could prove valuable for examining the neurological mediators of interpersonal phenomenon in organizations, from consensus formation and the nature of conflict to the development of shared cognition and emotional contagion.

While reductive organizational neuroscience favours the ‘direct’ measurement of brain processes as antecedents of organizational behavior, it should be clear from the examples we have provided throughout that neuroimaging and other direct neuroscientific measures are not always necessary to capitalize on insights regarding the functioning of the human brain. Rather, it seems possible and desirable to adopt the methods of translational research (Sharp et al., 2012) – using mixed, multi-level methods to transfer insights from base sciences to new applications in a manner that fits the needs of the domain of application.

Loewenstein and his colleagues (Loewenstein, 2006; Loewenstein, Rick and Cohen, 2008) have illustrated the possibilities of translational research for using neuroscience in social science. Their research on the pain and pleasure of information in economic decisions draws directly on neuroimaging studies showing that information signaling negative prospects activates regions of the brain's pain matrix. Because people derive pain (and pleasure) from information directly, not only from the material benefits it confers, they avoid painful information even when this might confer long-term benefit and satiate on pleasurable information that provides marginal functional gains. From this foundation, Karlsson, Loewenstein and Seppi (2009) analysed computerized records to show that investor behaviour manifested the same 'ostrich effect' – investors check their stocks more when the general stock market is up rather than down to avoid the pain of negative information. Analogously, MOS researchers could examine, using field experiments, surveys and/or indirect secondary data, the extent to which managers making strategic decisions exhibit selective attention to internal and external events based on the pleasure and pain of the information conferred about those events. Translational research seems well suited for using basic neuroscientific insights to enrich MOS, while exploiting social scientific research methods that are more familiar to organizational researchers, including laboratory and field experiments, observational methods, and computer simulation. Advances in our understanding of the neural mechanisms harnessed by organizational actors change what we look for when using conventional research methods.

Concluding remarks

If neuroscientists and organizational researchers are to engage in collaborative research of the kind envisaged by Senior et al. (2011), as cross-functional teams working for the benefit of *both* disciplines, we suggest that adopting a more socially situated perspective on cognition in organizations will be vital, particularly for the advancement of MOS.

Offering a critical realist alternative, we have demonstrated that grounding neuroscientific analyses of organizational behavior in emergent powers materialism affords a significant role to neurobiological factors, not as prime determinants, but rather as biophysical roots on which purposive human activity draws in tandem with other social, environmental, and technological resources.

Overcoming the reductionist objections to organizational neuroscience demands ontological give and take by MOS scholars located on both sides of what is clearly one of the field's main inter-disciplinary fault lines. As we have seen, advocates of organizational neuroscience, stemming primarily, although by no means exclusively, from a psychological background, need to engage more deeply with ongoing debates pertaining to the notion of emergence, to reaffirm the central importance of social and organizational levels of analysis in their work. Equally, however, although there are many instances where higher-level processes do indeed drive much of individual and collective behavior, not all human behavior is irreducible in the manner thus portrayed by the field's main detractors. The latter camp also must surely recognize that a host individual level mechanisms need to be incorporated, if MOS is to move beyond the present impasse and thus advance accounts of human behavior that reflect more fully the rich complexities of organizational life.

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